THE *MUSCA SORBENS* WIEDEMANN COMPLEX IN KWAJALEIN ATOLL, MARSHALL ISLANDS[1,2]

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ABSTRACT: Flies of the *Musca sorbens* Wiedemann complex, possessing characteristics of both the narrow and broad frons forms, were detected in Kwajalein Atoll, Marshall Islands in 1972. However, only the narrow frons form is thought to reproduce there, the broad frons form probably being excluded competitively from the islands during sporadic invasions. The narrow frons form present is probably the Australian, *M. vetustissima* Walker. A comparison with other Pacific Islands where either one form or the other occurs, suggests that sympatry between the African broad frons and Australian narrow frons forms is impossible presently. The pattern of female setulae on the lower parafrontalia rather than their number might be a more reliable female characteristic to distinguish the two major forms.

DESCRIPTORS: Diptera, *Musca sorbens* Wiedemann complex, Kwajalein Atoll, Marshall Islands.

Flies of the *Musca sorbens* Wiedemann complex became prominent in Kwajalein Atoll, Marshall Islands after a presumed invasion in the middle 1960's. Investigations were made in 1971 into the biological-integrated control of this complex and other lesser important flies, and a noticeable reduction was achieved through the introduction of natural enemies, the curtailment of breeding habitats, and the use of poisoned baits (Legner *et al.*, 1974). Considerable numbers of adult specimens were collected during the course of these studies, and the present investigation was made to characterize the biotypes of the *M. sorbens* complex present in the atoll with the criteria of Paterson and Norris (1970). According to these authors, two distinct forms exist in Africa, the

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broad and narrow frons forms which are ethologically and partially cytologically isolated from each other and from the Australian form. The latter resembles the African narrow frons form most closely in structure, but is distinct in chromosome morphology (Boyes et al., 1964). Typically, the broad frons form is predominant in the more tropical portions of Africa, although some overlap occurs (Paterson and Norris, 1970).

MATERIALS AND METHODS

Adult flies were either trapped with rotting egg baits or reared from larvae collected in dog and pig faeces. Collections were made between April 1971 and November 1973, during 3 trips on several islands in Kwajalein Atoll. This atoll, the largest in the world, is about 120 km long by an average 23 km wide, and contains 93 islets grouped between 166-167° E. longitude and 8-9° N. latitude in an irregular ring around a central lagoon (Legner et al., 1974). Kwajalein, the largest island, lies at the extreme south of the atoll. A comparison collection was also obtained from Red Bluff, Western Australia in 1971.

Male and female specimens were mounted on points. In the males, the least width of the frons and the greatest width of the head were measured. An accurate alignment of the heads was assured before measurement. In females, the number and arrangement of the setulae on the lower part of the parafrontalia, below the proclinate bristles situated near their middle, were recorded. Measurements and counts were made with an eyepiece micrometer on a stereomicroscope. All specimens keyed out to *M. sorbens* as recognized by van Emden (1939).

Collections made in the course of this study were probably very representative of the *M. sorbens* population in any given locality, as it was shown previously that almost the entire adult population on the largest island, Kwajalein, could be eliminated with poisoned baits in 48 hr (Legner et al., 1974).

RESULTS AND DISCUSSION

Existence of *M. sorbens* Forms in Kwajalein

Figure 1 diagrams frequency distributions of the male frons/head ratios for 11 collections and Figure 2 the number of setulae on female parafrontalia for 12 collections in Western Australia and Kwajalein Atoll. Figure 3 shows the combined frequency distribution of the frons/head ratios and number of setulae from all collections in Kwajalein Atoll. Statistical details of these measurements are shown in Tables I and II.

The total distribution of the male frons/head ratios (Fig. 3a) fits the Australian form diagrammed in Paterson and Norris (1970) most closely, with a low frequency of individuals showing African broad-frons form characteristics. The size of these flies as judged by head and frons measurements, was similar in all collections (Table II). The distribution of female setulae tends to support an intermediate form or one most closely related to the broad frons form (Fig. 3b).

A low frequency of broad frons males is apparent in only two of the collections on Kwajalein Island made in November 1972 and in October 1973 (Fig. 1, Table I). This form, as judged by the frons/head ratio, was apparently absent from other islands of the atoll. Females of the broad frons male form characteristically possess fewer setulae than the narrow frons form, and these are arranged in two distinct rows (Paterson and Norris, 1970). The value of this character was not positively assessed by these authors, and it appears that at least the numerical count is not reliable (Fig. 2).

The frons/head ratio data from males does not appear to indicate any hybridization between the two forms (Fig. 1), although admittedly the frequency of the broad frons form being as low as it is would make hybrid detection difficult. The existence of hybrids would appear more probable in the data of female setulae (Table I and Fig. 2), although the variable nature of this characteristic makes interpretation doubtful. Although the

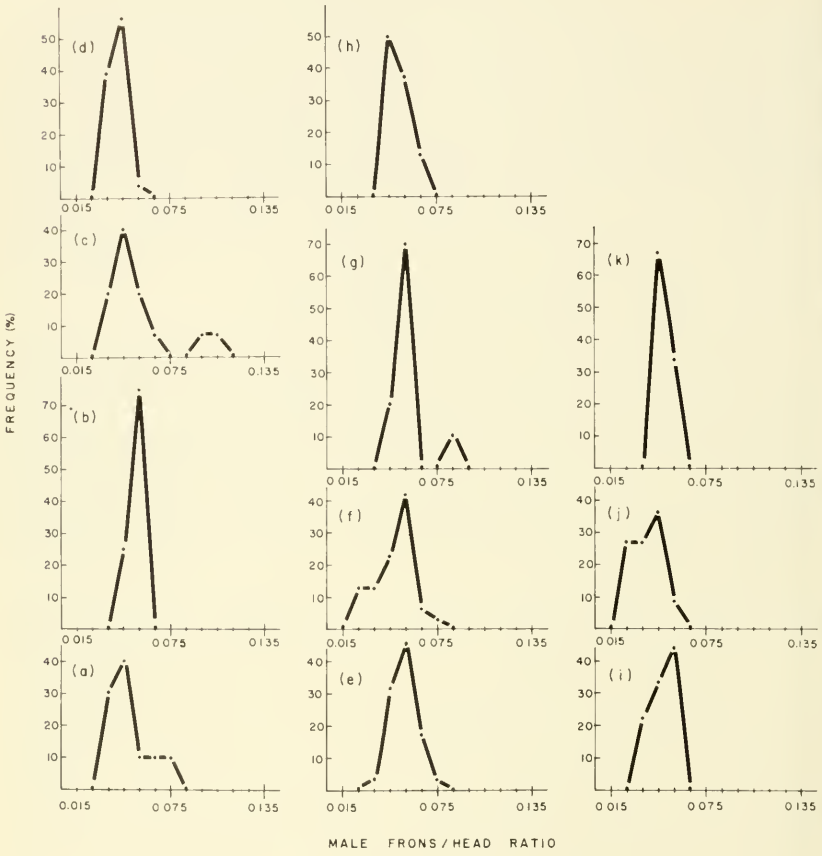

Fig. 1. Frons/head ratio frequency distribution for wild-caught and reared males of the *M. sorbens* complex in Western Australia and Kwajalein Atoll, Marshall Islands: (a) 10 males from Red Bluff, W. Aust., 11/7/71; (b) 4 males from Ennylabegan, Marshall Islands, 4/17/71; (c) 15 males from Kwajalein Is., M.I., 11/15/72; (d) 23 males reared from larvae collected in dog dung, Kwajalein Is., 11/16/73; (e) 63 males attracted to baits at 1000 hrs on Kwajalein Is., 11/9/73; (f) 31 males baited at 1700 hrs; (g) 10 males baited at 0900 hrs on Kwajalein on 10/31/73; (h) 8 males baited at 1300 hrs; (i) 9 males baited on Kwajalein on 11/9/73; (j) 11 males reared from larvae collected in pig dung on Ennubirr, M.I., 11/7/73; (k) 6 males baited on Roi-Namur, M.I., 11/8/73.

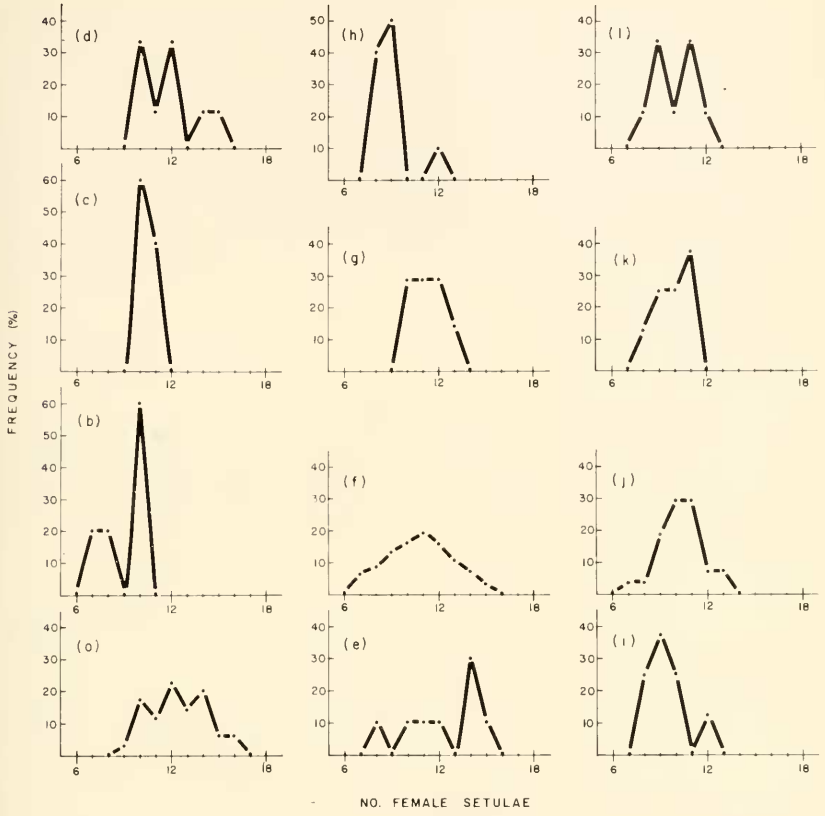

Fig. 2. Frequency distribution of number of setulae on lower parafrontalia in wild-caught and reared females of the *M. sorbens* complex in Western Australia and Kwajalein Atoll, Marshall Islands: (a) 35 females from Red Bluff, W. Aust., 11/7/71; (b) 5 females from Kwajalein Is., Marshall Islands, 4/26/71; (c) 4 females from Ennylabegan, M.I., 4/17/71; (d) 9 females from Kwajalein Is., 11/18/72; (e) 10 females reared from larvae collected in dog dung, Kwajalein Is., 11/15/73; (f) 97 females attracted to baits at 1000 hrs on Kwajalein Is., 11/9/73; (g) 7 females baited at 1700 hrs; (h) 10 females baited at 0900 hrs on Kwajalein on 10/31/73; (i) 8 females baited at 1300 hrs; (j) 27 females baited on Kwajalein on 11/9/73; (k) 8 females reared from larvae collected in pig dung on Ennubirr, M.I., 11/7/73; (l) 9 females baited on Roi-Namur, M.I., 11/8/73.

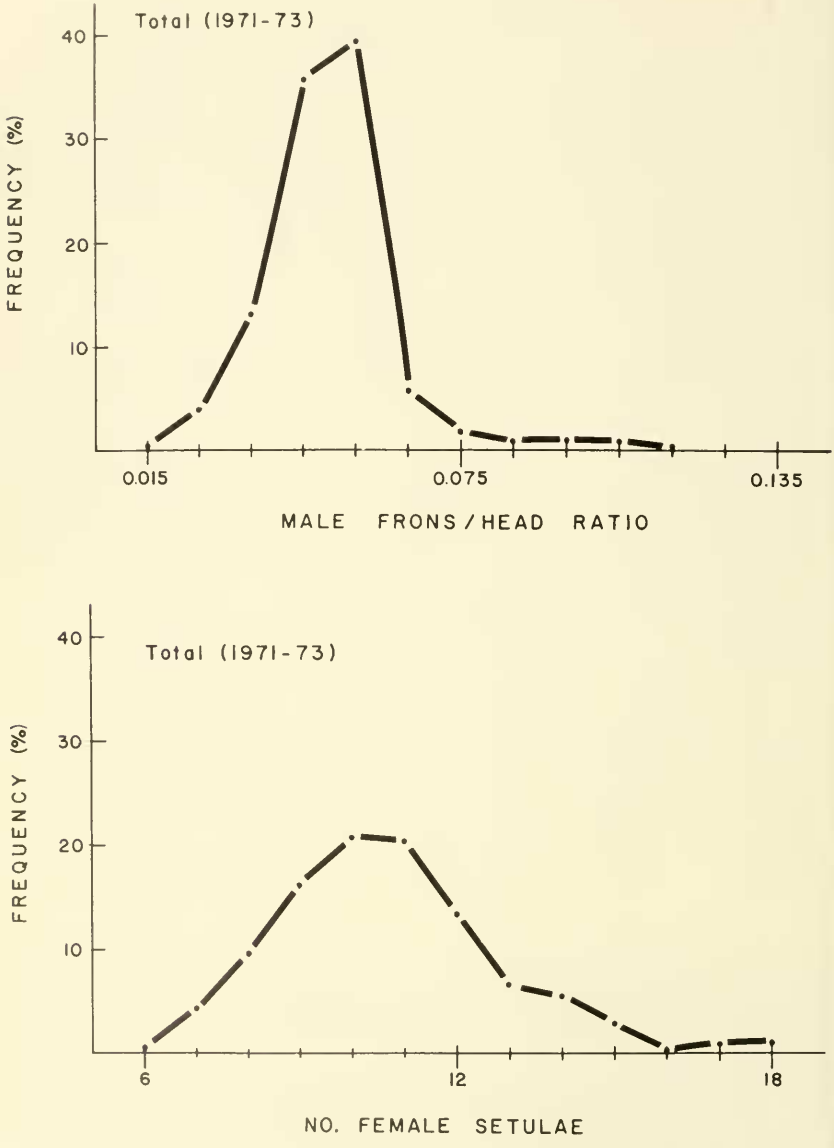

Fig. 3. Frequency distributions determined for all adults of the *M. sorbens* complex collected in Kwajalein Atoll, Marshall Islands from April 17, 1971 through November 16, 1973: (a) frons/head ratio of 181 males; (b) number of setulae on lower parafrontalia in 195 females.

means of the number of setulae fall much closer to the Salisbury (broad-frons males) form than they do to the Canberra colony (narrow-frons males) studied by Paterson and Norris (1970) (Table 1), in most cases they were distinctly scattered on the examined specimens, rather than being arranged in distinct rows, thus fitting the pattern of the form where males have a narrow frons/head ratio. Therefore, the *pattern* of setulae and not their number might be the more reliable female characteristic to distinguish the two major forms.

Hours of Flight Activity

Comparisons of flight activity in the morning hours with later hours of the day did not reveal any significant differences among the individuals collected (Table I and Figs. 1 and 2). The narrow frons form was prevalent in all collections.

Breeding Habitats

Flies that were collected as larvae in dog and pig faeces and reared to adults belonged to the narrow frons form. Moreover, there were no significant differences between the reared adults and those collected simultaneously on baits in the same area (Table 1). Dog and pig faeces were previously found to be the principal breeding habitats of these flies in the atoll (Legner et al., 1974).

Possible Origin of Flies of the *M. sorbens* Complex in Kwajalein

Although most of the flies in Kwajalein probably had their origins in Australia as judged by the male frons/head ratio data (Paterson and Norris 1970; Fig. 1, Table I), the existence of the broad frons type in low frequencies suggests another invasion source, possibly from Hawaii or Malaysia, where only the broad frons form has been reported (Paterson and Norris, 1970).

The stability of the broad frons form in Kwajalein is questionable, however, as it was only detected on Kwajalein Island

on two collection dates in 1972 and 1973 (Fig. 1c, g). Kwajalein is the only island in the atoll which receives direct international flights and shipping. Thus, it would be the logical invasion site. However, the apparent lack of persistence of this form on the island as judged by its sporatic collection over 3 years may indicate an inability for sustained reproduction. Repeated invasions from abroad may explain its sporadic appearance.

Where the two forms meet on Kwajalein Island, there is no conclusive evidence of hybridization. Paterson and Norris (1970) inferred from crossing and choice experiments that the two narrow frons forms would be completely reproductively isolated were they to overlap in nature. They already knew from areas of sympatry in Africa that the narrow and broad frons forms did not hybridize. Assuming that the narrow frons form in Kwajalein is of Australian and not African origin, a probability evidenced by the similarity of the frons/head frequency distribution curves to an Australian population (Paterson and Norris, 1970 and Figs. 1 and 3a), then there also appears to be no hybridization between broad frons African and narrow frons Australian forms. Indeed, the two may never be capable of exhibiting sympatry, as competitive exclusion by the Australian narrow frons form may occur repeatedly in Kwajalein. Similarly, competitive exclusion favoring the broad frons form may occur in Hawaii and Malaysia.

The available evidence suggests that African broad frons form *M. sorbens* and Australian narrow frons form *M. vetustissima* Walker may inhabit Kwajalein atoll, but only the latter form breeds successfully there.

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Table I. Statistical details of male frons ratios and number of female setulae in samples from Kwajalein Atoll and Red Bluff, Western Australia

Sample[1]	Date	Measurement[2]	n	$\bar{x}$	s	$s_{\bar{x}}$	
Red Bluff, W. Aust.	11/7/71	f.r.	10	0.047	0.012	0.004	0.036-0.071
		s.	35	12.4	1.834	0.310	9-16
Ennylebegan, M.I.	4/17/71	f.r.	4	0.050	0.002	0.001	0.048-0.053
		s.	4	10.3	0.500	0.250	10-11
Kwajalein Is., M.I.	4/26/71	f.r.	–	–	–	–	–
		s.	5	9.0	1.414	0.632	7-10
Kwajalein Is., M.I.	11/15/72	f.r.	15	0.055	0.021	0.005	0.030-0.105
		s.	9	11.8	1.787	0.596	10-15
Kwajalein Is.	10/31/73	f.r.	10	0.055	0.010	0.003	0.040-0.081
0900 hrs	10/31/73	s.	10	8.9	1.197	0.379	8-12
1300 hrs	10/31/73	f.r.	8	0.052	0.007	0.003	0.042-0.062
		s.	8	9.4	1.302	0.460	8-12
08-1700 hrs	10/31/73	f.r.	9	0.049	0.007	0.002	0.039-0.059
		s.	27	10.3	1.382	0.266	7-13
Kwajalein Is.	11/9/73	f.r.	63	0.052	0.008	0.001	0.039-0.800
1000 hrs		s.	97	10.7	2.084	0.212	7-15
1700 hrs		f.r.	31	0.048	0.012	0.002	0.022-0.071
		s.	7	11.3	1.113	0.421	10-13
Kwajalein Is.	11/16/73	f.r.	23	0.042	0.006	0.001	0.033-0.051
reared dog dung		s.	10	13.3	3.093	0.978	8-18
Enubuj, M.I.	11/7/73	f.r.	11	0.038	0.009	0.003	0.027-0.054
reared pig dung		s.	8	9.9	1.126	0.398	8-11
Roi-Namur, M.I.	11/8/73	f.r.	6	0.048	0.004	0.002	0.041-0.053
		s.	9	10.1	1.537	0.512	8-13
Total Kwajalein	4/17/73	f.r.	181	0.049	0.011	0.001	0.022-0.105
(all localities	to	s.	195	10.6	2.031	0.145	7-18
& collections)	11/16/73						

[1] Collected with rotting egg baits unless otherwise indicated.
[2] f.r. = male frons/head width ratio; s. = No. female setuale on lower parafrontalia.

Table II. Average measurements of male frons and head width in samples from Kwajalein Atoll and Red Bluff, Western Australia

Sample[1]	Date	Width Measured	n	$\bar{x}$ (in mm)	s	$s_{\bar{x}}$	Range
Red Bluff, W. Aust.	11/7/71	frons	10	.079	.015	.005	.063 - .100
		head		1.740	.327	.103	1.300 - 2.200
Ennylebegan, M.I.	4/17/71	frons	4	.078	.008	.004	.067 - .083
		head		1.578	.156	.078	1.40 - 1.70
Kwajalein Is., M.I.	11/15/72	frons	15	.097	.039	.010	.05 - .200
		head		1.781	.153	.039	1.50 - 2.10
Kwajalein Is.	10/31/73	frons	10	.101	.027	.008	.067 - .170
		head		1.823	.144	.046	1.650 - 2.100
1300 hrs	10/31/73	frons	8	.095	.014	.005	.072 - .117
		head		1.829	.143	.050	1.7 - 2.1
08-1700 hrs	10/31/73	frons	9	.089	.007	.002	.083 - .100
		head		1.841	.214	.071	1.5 - 2.15
Kwajalein Is.	11/9/73	frons	63	.099	.019	.002	.083 - .163
1000 hrs		head		1.941	.190	.024	1.550 - 2.450
1700 hrs	11/9/73	frons	31	.095	.028	.005	.046 - .150
		head		1.99	.199	.036	1.675 - 2.300
Kwajalein Is.	11/16/73	frons	23	.087	.013	.003	.067 - .113
reared dog dung		head		2.149	.149	.031	1.9 - 2.375
Enubuj, M.I.	11/7/73	frons	11	.072	.018	.006	.050 - .109
reared pig dung		head		1.89	.089	.027	1.750 - 2.000
Roi-Namur, M.I.	11/8/73	frons	6	.090	.016	.007	.071 - .117
		head		1.883	.244	.099	1.65 - 2.35
Total Kwajalein	4/17/71	frons	181	.089	.022	.022	.046 - .200
(all localities	to	head		1.859	.214	.017	1.30 - 2.45
& collections)	11/16/73						

[1]Collected with rotting egg baits unless otherwise indicated.